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GROUND-WATER RESOURCES OF THE

SANTA YNEZ UPLAND GROUND-WATER BASIN

SANTA BARBARA COUNTY, CALIFORNIA

By

G. F. LaFreniere and J. J. French

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# GROUND-WATER RESOURCES OF THE SANTA YNEZ UPLAND GROUND-WATER BASIN

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## ABSTRACT

This report on the Santa Ynez basin is one of a series on Santa Barbara County prepared by the U.S. Geological Survey in cooperation with the Santa Barbara County Water Agency.

The Santa Ynez upland ground-water basin in the south-central part of the county is a wedge-shaped 130-square-mile area narrowing eastward with the Santa Ynez River forming its southern boundary. Along most of its course bordering this area, the Santa Ynez River is confined in a fairly narrow shallow inner valley cut in consolidated rocks. The dissected area north of the river broadens westward and contains a terraced upland which forms the bulk of the unconsolidated deposits in which the ground water in the basin is stored. These deposits are of Tertiary and Quaternary age and consist of the Careaga Sand, Paso Robles Formation, terrace deposits, and alluvium. Their combined thickness is as much as 2,000 feet in the northwestern part of the basin.

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There are three distinct water bodies in the Santa Ynez upland basin. They are:  A shallow, semiperched water body in the Paso Robles Formation on the western side of the terraced upland; the main water body in the Paso Robles Formation; and a confined water body in the Careaga Sand.

Ground water in the area moves readily through the alluvium-filled stream valleys, because the permeability of these deposits is high. However, where the valleys are narrow and the cross-sectional area of alluvial fill is decreased, water is forced to the surface to move as intermittent or perennial flow in the stream channels.

The total storage capacity of the Santa Ynez upland ground-water basin is about 10 million acre-feet.  However, under present conditions it is economically feasible to pump water from only the upper 200 feet of the saturated deposits, which limits usable storage to about 1 million acre-feet.  The total reduction in the amount of ground water in storage during the period 1945-64, as calculated from water-level change maps, was 60,000 acre-feet.

Ground-water outflow from the basin for the 19-year period 1946-64 was estimated to total 218,000 acre-feet.  This total represents 146,000 acre-feet of pumpage, 19,000 acre-feet of evapotranspiration, and 53,000 acre-feet of ground-water outflow in streams.

Estimated ground-water inflow or recharge to the basin for the same period consisted of 70,000 acre-feet from infiltration of rain, 29,000 acre-feet from irrigation-return water, and about 59,000 acre-feet from seepage losses in streams, or total recharge to the basin of 158,000 acre-feet for the 19-year period.

An exact estimate of the perennial yield of the Santa Ynez upland ground-water basin is impossible because of a lack of complete data on ground-water outflow and inflow covering both a dry and wet period. However, if in the future, optimum use is made of all ground water in the basin and nearly all natural discharge is prevented, the perennial yield would be equal to the long-term recharge.  Thus, if most phreatophytes along the streams were removed and nearly all natural outflow prevented, the incomplete data suggest that a perennial yield of about 7,000 to 7,500 acre-feet per year could be expected.

Most of the ground water in the Santa Ynez upland basin meets the chemical quality standards set for stock and irrigation use.  Most of the ground water in the basin is very hard and has a total dissolved-solids content in excess of 500 ppm (parts per million).

## INTRODUCTION

### Background, Purpose, and Scope

For many years Santa Barbara County, in contrast to other counties in southern California, had a very low rate of population increase. In the mid-1950's, however, the rate began to rise, primarily because of the pressure of the ever-increasing population growth of the metropolitan areas in the counties to the south and east. In 1960 the population of Santa Barbara County was 169,000; in 1965 it approached 200,000; and by 1990 it is expected to reach 400,000. To sustain this growth in population, a long-term plan for future water supplies is required.

The purpose of this report on the Santa Ynez upland ground-water basin (fig. 1) is to make available to the Santa Barbara County Water Agency information on which to base their plans for future utilization and distribution of supplemental water to be received under the California Water Plan.

FIGURE 1.--Map of Santa Barbara County, Calif., showing Santa Ynez upland ground-water basin.

The scope of this investigation includes:  (1) Compilation of a geologic map and delineation of the ground-water basin margins; (2) determination of the inflow-outflow relation of the aquifer system; and (3) evaluation of the quantity of water in storage in the ground-water basin, changes in the quantity of ground water in storage, and the significance of these quantities with reference to the perennial yield of the basin.

During the progress of the investigation the scope was expanded to include a study of the effect of Cachuma Reservoir on ground-water recharge to the Santa Ynez upland ground-water basin.

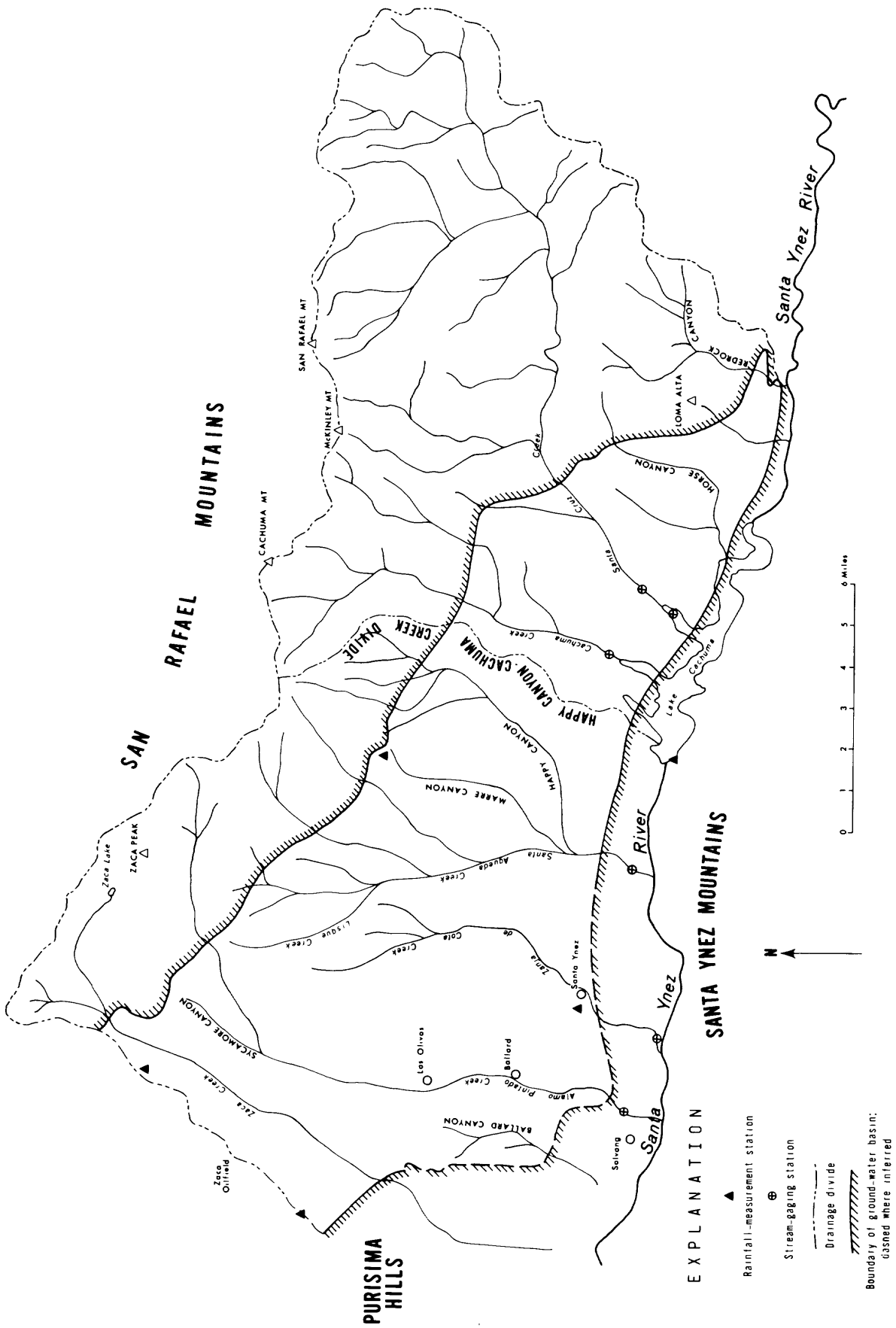## Location and General Features

The Santa Ynez upland ground-water basin (fig. 2) is north of the Santa Ynez River about 25 miles inland from the Pacific Ocean.  It is about 20 miles from Santa Barbara across the Santa Ynez Mountains.

The ground-water basin is a wedge-shaped area, narrow toward the east. The Santa Ynez River roughly parallels the southern boundary of the basin, but is separated from it by a nearly continuous barrier of impermeable rocks.  The impermeable rocks of the San Rafael Mountains form the northern boundary.  The basin underlies the Santa Ynez upland and the adjoining foothills (fig. 3).

The Santa Ynez upland is 150 to 200 feet above the Santa Ynez River, at its south end, and abuts against the dissected foothills of the San Rafael Mountains north and east of Los Olivos.  It is bordered on the west by the valley of Alamo Pintado Creek and on the east by the valley of Santa Agueda Creek.  The area, described in detail by Upson (Upson and Thomasson, 1951, p. 41-42), is nearly 15 square miles and constitutes the major agricultural area within the basin.  The adjoining dissected foothills overlie the greater part of the ground-water basin.

The total area of the Santa Ynez upland ground-water basin is about 130 square miles.  The land-surface elevation ranges from 480 feet along the Alamo Pintado Creek near Solvang to about 2,390 feet in the foothills in the northeast corner of the basin.  The San Rafael Mountains immediately north and northeast of the basin rise to an irregular crest, 4,000 to 6,000 feet above sea level.

The vegetation on the hilly parts of the area consists mainly of sparse to thick brush interspersed with chaparral, live oak, and grassland.  Crops and grazing land cover the terraced upland area.

FIGURE 2.—Map of Santa Ynez upland ground-water basin, showing location of stream-gaging stations and rainfall-measurement stations.

## Previous Investigations and Acknowledgments

The earliest published geologic report on the Santa Ynez upland area was by Nelson (1925), who mapped the geology of the eastern part of the upland in detail. The western and central parts of the upland were later mapped by Upson (Upson and Thomasson, 1951) and by Dibblee (1950). The earliest published description of the general hydrology of the Santa Ynez upland area was in a report by Upson and Thomasson (1951) on the water resources of the Santa Ynez River basin. Wilson (1959) made an appraisal of the ground-water withdrawals from the entire Santa Ynez River basin for the period 1945-52. He concluded (p. 54) that in the central part of the Santa Ynez upland ground-water basin there was a probable overdraft of ground water.

In 1961 Bekir Apeydin, a Turkish trainee, sponsored by the U.S. Agency for International Development and working with the U.S. Geological Survey, calculated the average specific yield for sediments in the Santa Ynez upland ground-water basin on the basis of available well-log data. These specific yields were used in this report to compute ground-water storage in the basin.

Appreciation and acknowledgment are expressed to the many organizations that contributed geologic and hydrologic data for use in preparing this report. These include the Union, Tidewater, and Shell Oil Cos., California Division of Oil and Gas, Santa Ynez River Water Conservation District, and the Pacific Gas and Electric Co.

This investigation was made by the U.S. Geological Survey in cooperation with the Santa Barbara County Water Agency. It was under the general supervision of Walter Hofmann, district chief in charge of water-resources investigations in California, and under the immediate supervision of L. C. Dutcher, chief of the Garden Grove subdistrict office.

## Well-Numbering System

Wells are numbered according to their location in the rectangular system of subdivision of public land. Where the land has not actually been surveyed, appropriate subdivisions are projected. A well number, such as 6N/30W-3A1, has two parts. The part that precedes the hyphen indicates the township and range (T. 6 N., R. 30 W.). The numbers following the hyphen indicate the section (sec. 3); the letter indicates the 40-acre subdivision of the section, as shown in the accompanying diagram; and the final number is the serial number in the particular 40-acre tract. Accordingly, well 6N/30W-3A1 is the first well listed in the NE¼NE¼ sec. 3, T. 6 N., R. 30 W., San Bernardino base line and meridian.
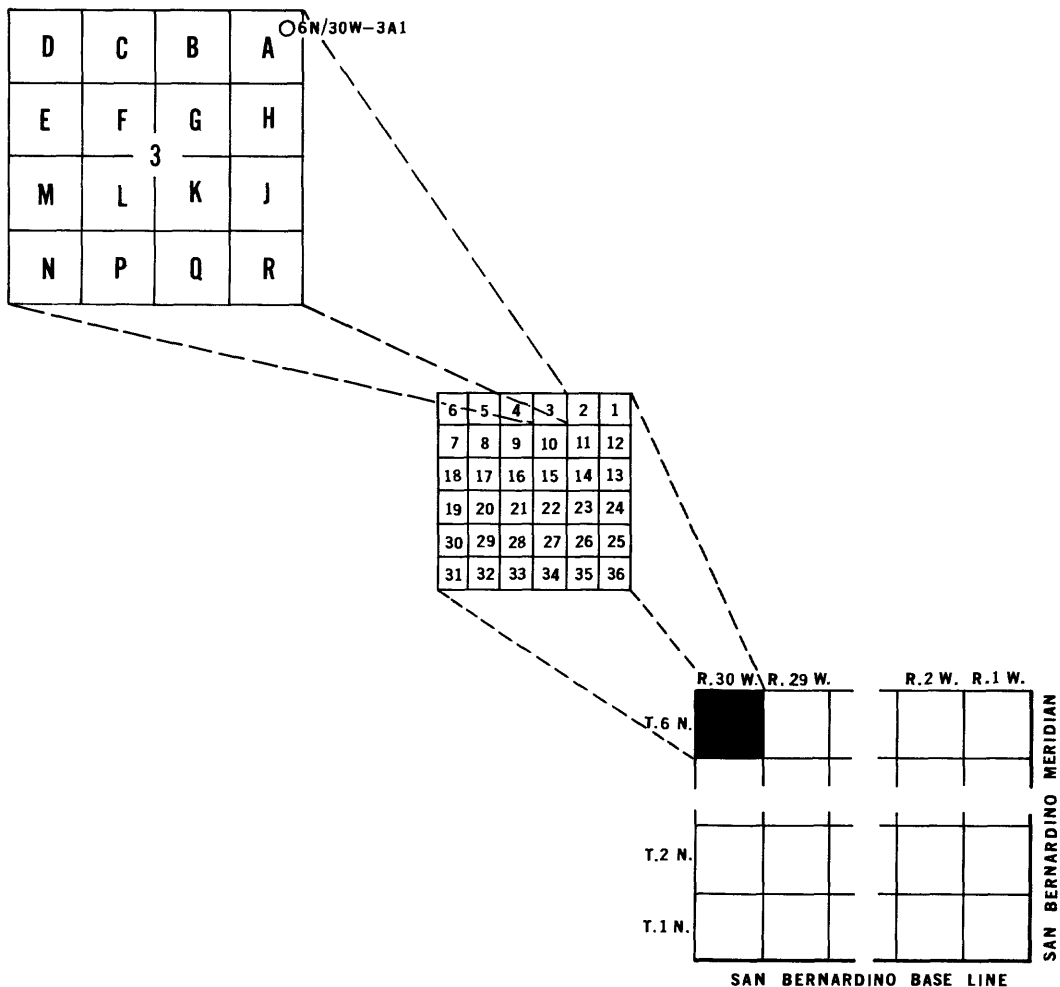
## GROUND-WATER GEOLOGY

In this report the geologic formations have been differentiated into two main groups according to their water-bearing character--consolidated rocks and unconsolidated deposits.

The consolidated rocks have been subdivided into basement complex of pre-Tertiary age and Tertiary rocks (fig. 3). These consolidated rocks, in some areas, may yield small quantities of ground water from fractures, but do not yield significant quantities of water to wells. They are important because they form the boundaries of the ground-water basin.

The unconsolidated deposits overlie the consolidated rocks and form the main ground-water basin. They are of Tertiary and Quaternary age and consist of the Careaga Sand, Paso Robles Formation, terrace deposits, and alluvium. Their combined thickness is as much as 2,000 feet in the northwest part of the basin.

### Basement Complex

The basement complex in the Santa Ynez area consists of the Franciscan Formation and sedimentary rocks, both of pre-Tertiary age.

The Franciscan Formation is a highly sheared and deformed sequence of shale, sandstone, and basalt, with some intruded serpentinized ultrabasic rock. The sedimentary rocks, which overlie the Franciscan Formation along the basin margin between Happy Canyon and Cachuma Creek, consist of impermeable brown shale and sandstone.

As shown in figure 3, the southwest front of the San Rafael Mountains is made up largely of basement complex that is faulted over the upturned edges of the younger sedimentary formations to the south. Immediately north of the fault zone, which forms part of the boundary of the ground-water basin, striking monolithic outcrops of red chert and serpentine have been etched out of the rocks of the basement complex by differential weathering and erosion.

## Tertiary Rocks

The consolidated Tertiary rocks in the Santa Ynez area range in age from middle Miocene to late Pliocene and consist of cherty and diatomaceous shale, siltstone, sandstone, diatomite, and some limestone. These rocks attain a thickness of several thousand feet and include the Monterey Shale, the Sisquoc Formation, the Tequepis Sandstone of Nelson (1924), and the Foxen Mudstone. They are of marine origin and unconformably overlie the basement complex. In the south and east parts of the upland area they form the boundary of the ground-water basin.

In general these rocks are not water bearing, except in the Ballard Canyon area where a highly fractured cherty shale is present. A sandstone which crops out along the southeast edge of the storage basin and borders Lake Cachuma between Cachuma and Horse Canyons is, in places, only partially consolidated. Although locally saturated where inundated by the lake, the sandstone is not considered an important water-bearing unit.

## Careaga Sand

The Careaga Sand is a marine deposit of late Pliocene age. Its stratigraphic relation with older rocks is varied. In the deeper parts of the basin, mudstone, claystone, and siltstone of the older consolidated rocks grade upward into the Careaga Sand. Along the margins of the upland area and on the southeast flank of the Purisima Hills the Careaga Sand overlies the consolidated Tertiary rocks with angular unconformity. Dibblee (1950) suggested that the sand which crops out in the Purisima Hills east of Zaca Creek may be younger than the Careaga Sand.

Lithology, thickness, and extent.--The Careaga Sand crops out discontinuously around the margins of the Santa Ynez upland ground-water basin. Outcrops about 100 yards wide extend from the eastern extremity of the basin along its south boundary to the vicinity of Santa Agueda Creek where the formation is concealed beneath an extensive cover of terrace deposits. The Careaga Sand is exposed on the southeast flank of the Purisima Hills in gently dipping beds which underlie several square miles of the Ballard Canyon area. West of Zaca Creek outcrops of Careaga Sand trend northwest along the north flank of the Purisima Hills. Careaga Sand also crops out in the northwest corner of the basin, and scattered outcrops are present north and south of the fault which bounds the basin on the north. Water wells drilled by the Tidewater Oil Co. in the Zaca oilfield show that where the Careaga Sand occurs along the Zaca anticline, it is buried under only a few tens of feet of terrace deposits.

Data from 20 wildcat wells show that the Careaga Sand covers all but a few of the structural highs in the Santa Ynez upland area. The average thickness is about 800 feet, but along the margins of the area it thins to 200 feet or less.

Generally, the unit thins from west to east with concomitant changes in lithology. In most of the area the Careaga Sand consists chiefly of gray-white to buff, massive, fine to medium sand, generally coarser in the upper part. Thin lenses of pebbles consisting of chert, quartzite, and volcanic rock occur locally in the upper part of the formation.

Logs from wildcat oil-test wells 7N/31W-24J1 and 7N/30W-19H2 (fig. 4) show that in the central part of the ground-water basin where the Careaga Sand is about 900 feet thick, gray to greenish-white fine sand alternate with considerable quantities of clay and silt. Gypsiferous, tuffaceous, and bentonitic beds are scattered throughout the section. The electric logs in figure 4 show that at least in this area the Careaga Sand has a uniform thickness and lithology which extends for 4 miles roughly parallel to the strike of the folds within the basin.

Water-bearing properties.--Few wells have penetrated the Careaga Sand in the Santa Ynez upland ground-water basin because of its great depth throughout all but the marginal areas of the basin. Consequently, few data are available concerning its water-bearing properties. Upson (Upson and Thomasson, 1951, p. 33-34) calculated the average coefficient of permeability for the Careaga Sand on the basis of laboratory tests made on a small number of samples collected from the hills bordering the Lompoc plain in western Santa Barbara County. Four samples, typical of nonindurated Careaga Sand, had an average coefficient of permeability of about 70 gpd (gallons per day) per square foot.

Upson (Upson and Thomasson, 1951, p. 33) mentioned that wells which penetrate the Careaga Sand beneath the Lompoc plain were cemented off by drillers, because, when the wells were pumped they sanded up, and also, because greater yields were obtained from the overlying alluvium. Since 1951, however, improved well-completion techniques in wells drilled in the Careaga Sand of the Santa Ynez valley west of the upland have resulted in yields of several hundred gallons per minute or more.

Several domestic wells penetrate the Careaga Sand in the Ballard Canyon area and produce water of good quality. Well 7N/31W-34M1 in this area was pumped at rates up to 133 gpm (gallons per minute) and had a specific capacity (gallons per minute pumped for each foot of drawdown) slightly greater than 1.

Four water wells drilled by the Tidewater Oil Co. near the Zaca oilfield and perforated in the Careaga Sand had specific capacities ranging from 2 to 7 and averaging about 5. The highest yielding well was pumped at 350 gpm with 50 feet of drawdown.

## Paso Robles Formation

The Paso Robles Formation is a nonmarine deposit of late Pliocene and probable early Pleistocene age. Generally, it conformably overlies the Careaga Sand but in the extreme southeast part of the area, where the Careaga Sand was not deposited or has been removed by erosion, the Paso Robles Formation rests unconformably on older consolidated rocks. Terrace deposits and alluvium unconformably overlie the Paso Robles Formation. In places the Paso Robles Formation cannot be distinguished from the terrace deposits by lithology, and it is necessary to rely on the different degree of deformation of the two units to distinguish between them. The Paso Robles Formation and the underlying Careaga Sand have been deformed moderately throughout the basin and, locally, are overturned along the faults which bound the basin on the north. In contrast, the terrace deposits have been uplifted and tilted only slightly. The terrestrial Paso Robles Formation can be distinguished from the marine Careaga Sand by its coarseness and heterogeneity and by the absence of marine fossils.

Lithology, thickness, and extent.--The Paso Robles Formation underlies all but a few square miles of the Santa Ynez upland ground-water basin and includes about 70 percent of the surface outcrops (fig. 2). North and east of the terraced Santa Ynez upland the Paso Robles Formation has been uplifted and dissected into a northwest-trending foothill area.

The formation consists of poorly consolidated terrestrial gravel, sand, silt, and clay. The sediments are largely stream deposited and are lenticular and heterogeneous. The gravel is commonly crossbedded, light gray, and usually contains an abundance of white shale pebbles derived from the Monterey Shale (Miocene). The sand is generally cream buff, crossbedded, poorly sorted, and contains large quantities of clay and scattered lenses of gravel. The clay is generally greenish gray, but locally may be light red.

Although no formal sequence of units is recognized for the Paso Robles Formation, Dibblee (1950) and Upson (Upson and Thomasson, 1951) have suggested a breakdown into upper and lower units. The lower part, which reaches a maximum thickness of about 2,000 feet in the San Rafael foothills, consists of greenish-gray clay with silt and sand and minor quantities of white shale-pebble gravel. This section is well exposed along the east side of Santa Agueda Creek. Farther east, in Johnson Canyon, the basal part of the Paso Robles Formation is coarser and contains red sand and thick, coarse gravel which is now inundated by an arm of Lake Cachuma. West of the Santa Ynez upland a massive clay with lenses of fresh-water limestone is usually present at the base of the formation. Fresh-water limestone also crops out in the Ballard Canyon area and along the west side of Alamo Pintado Creek, but does not occur farther east. However, the clay with which the limestone is associated seems to be continuous over the deeper parts of the basin. The continuity of the basal clay unit is shown in figure 4.

The upper part of the Paso Robles Formation consists chiefly of sand and gravel with minor quantities of silt and clay (fig. 4). The gravel, which is composed largely of white shale pebbles, becomes coarser toward the top of the formation. Near outcrops of the basement complex pebbles, cobbles, and boulders of jasper, serpentine, and basic volcanic rocks become more abundant and darken the color of the gravel.

The Paso Robles Formation has been deformed and uplifted intermittently since early Pleistocene time (Upson and Thomasson, 1951, p. 53). As a result, its thickness varies greatly over the ground-water basin, thinning over anticlines and reaching its greatest thicknesses in synclinal troughs. The average thickness of the Paso Robles Formation in 20 wildcat oil wells scattered throughout the basin is 1,470 feet. Many of these oil exploration wells were drilled on or near anticlinal axes; therefore, this figure may be 100 to 200 feet less than the actual average thickness. Well 7N/30W-28E1 (fig. 4) penetrates 2,450 feet of Paso Robles Formation and in the northwest corner of the basin where reverse faulting has deformed the basin sediments, well 8N/31W-24E1 passes through 4,150 feet of Paso Robles Formation. Dibblee (1950, p. 47) estimated a maximum thickness of 4,500 feet for the Paso Robles Formation adjacent to the San Rafael Mountains. Upson (Upson and Thomasson, 1951, p. 35) suggested a maximum stratigraphic thickness close to 3,000 feet in the upland area.

Water-bearing properties.--The Paso Robles Formation is the major
aquifer in the Santa Ynez upland ground-water basin. Although generally
less permeable than the overlying alluvium, it contains gravels which yield
sufficient water to wells for moderate irrigation. The formation contains
much clay and silt which decrease its permeability. Because of the
lenticular nature and heterogeneous lithology of the formation, relative
yields of water from wells only short distances apart may range from low to
high. In many parts of the area a well must penetrate a thousand or more
feet of the Paso Robles Formation to yield several hundred to a thousand
gallons per minute. Even drilling to these depths does not guarantee a well
yield of this magnitude. A 1,200-foot-deep well (7N/29W-28L1) drilled in a
predominantly fine-grained sequence of the Paso Robles Formation in Happy
Canyon produced only 50 gpm.

Four wells drilled by the Santa Ynez River Water Conservation District
and perforated in the Paso Robles Formation have depths of 667, 898, 1,005,
and 1,240 feet. These wells have specific capacities of 7, 10, 14, and 15,
respectively. The deepest well (7N/31W-23P7) when tested yielded 1,800 gpm
with 120 feet of drawdown. The lithologic and electric logs for this well
show that relatively clean gravel beds up to 70 feet thick occur
intermittently from 700 to about 1,200 feet below the land surface and are
overlain by a 700-foot-thick sequence of predominantly clay and clay-rich
gravel.

The deepest water well known to penetrate the Paso Robles Formation is
6N/30W-2N1. This well is 1,400 feet deep and penetrates 1,300 feet of the
formation. When first developed, the well produced about 1,300 gpm with a
drawdown of about 90 feet (specific capacity about 15).


## Terrace Deposits


The terrace deposits everywhere overlie the Paso Robles and older
formations with angular unconformity. Dibblee (1950, p. 50) suggested that
the oldest terrace deposits of the Santa Ynez upland may be correlative with
the Orcutt Formation of late Pleistocene age which crops out in areas to the
west of the Santa Ynez upland. The veneer of terrace deposits covers the
stream-cut benches along the Santa Ynez River and its major tributaries.

Lithology, thickness, and extent.--The terrace deposits in the upland
area consist of stream-laid gravel, sand, silt, and clay, and were
deposited at several levels by streams flowing south and southwest.  They
are crossbedded and consist of a large fraction of fine-grained sediment.
Generally, the terrace deposits contain abundant flat, rounded pebbles of
diatomaceous shale and porcelaneous chert and varying quantities of
detritus derived from the consolidated rocks.  In many places the terrace
deposits are indistinguishable lithologically from the underlying Paso
Robles Formation, and must be recognized by their lesser degree of
deformation.

The terrace deposits rarely exceed several tens of feet in thickness,
except in the north part of the Santa Ynez upland where, on the basis of
well-log data, Upson (Upson and Thomasson, 1951, p. 42) estimated the
maximum thickness to be 150 feet.

Extensive terrace deposits occur along Zaca and Santa Cruz Creeks and
Adobe Canyon.  Where Santa Cruz Creek crosses the fault which forms the
north boundary of the ground-water basin, five distinct levels of terrace
deposits occur at elevations extending up to more than 800 feet above the
present stream channel (fig. 3).  An area of several square miles of coarse
deposits extends from the lower reach of Happy Canyon to lower Cachuma
Creek.  These deposits have dips up to 15 degrees.  They contain numerous
boulders several feet in diameter.

Water-bearing properties.--Because the sediments in the terrace
deposits are poorly sorted, lenticular, and contain abundant fine-grained
material, they are only moderately permeable.  The deposits yield water to
wells throughout the Santa Ynez upland, but most wells which are more than
20 or 30 feet deep also draw water from the Paso Robles Formation.  Outside
the upland itself, the terrace deposits do not constitute an important
source of ground water, as they are only of limited areal extent and
thickness and are commonly above the zone of saturation.


## Alluvium


Alluvium is composed of stream-laid sediments which were deposited on
fans and along flood plains in Recent time.  These deposits unconformably
overlie all older formations.

Lithology, thickness, and extent.--The alluvium in the upland area consists of gravel, sand, silt, and clay. The deposits average several tens of feet in thickness, but in the major stream valleys the maximum thickness is about 100 feet. It has a maximum exposure width of about half a mile in the valleys of Alamo Pintado, Santa Agueda, and Zaca Creeks, and slightly less in Santa Cruz and Happy Canyons.

Water-bearing properties.--Since the earliest development of the Santa Ynez upland basin, the greatest concentrations of wells have been in the valleys of Alamo Pintado and Santa Agueda Creeks and in Happy Canyon. The first wells in those areas were shallow and drew water chiefly from the alluvium or from the terrace deposits. However, increased pumpage for irrigation and consequent lowering of water levels has necessitated deeper wells which often are perforated in both the alluvium and the Paso Robles Formation.

No data are available concerning the permeability of the alluvium in the Santa Ynez upland area. However, elsewhere in Santa Barbara County where data are available, the alluvium is generally more permeable than the older unconsolidated deposits. Test pumping of wells perforated in the alluvium in adjacent San Antonio Valley (Muir, 1964, p. 18) indicated specific capacities ranging from 8 to 13 with yields of about 350 gpm.


HYDROLOGY


Precipitation


The most important climatic feature in the Santa Ynez upland area, as in all southern California, is the seasonal distribution of precipitation. Although snow occasionally falls on the mountains and hills of the upper Santa Ynez valley, precipitation occurs predominantly as rain. The early storms normally occur in late October or November, and the wet season ends in April or May. Little or no rain falls during the dry season, which generally extends from May to November.

Precipitation records for the period 1946-64 at Santa Barbara and at four stations in the Santa Ynez upland basin are shown in table 1. The annual precipitation varies greatly within the basin. The long-term annual precipitation record at Santa Barbara (fig. 5) shows a high of 45.25 inches in 1941 and a low of 4.49 inches in 1877. The average annual precipitation for the 97 years of record is 17.79 inches. However, for the 19-year period 1946-64, the average annual precipitation is 2.5 inches below the long-term average or 15.3 inches. For the stations in the Santa Ynez upland, for the same 19-year period, precipitation averaged an inch or 2 less than for the station at Santa Barbara.
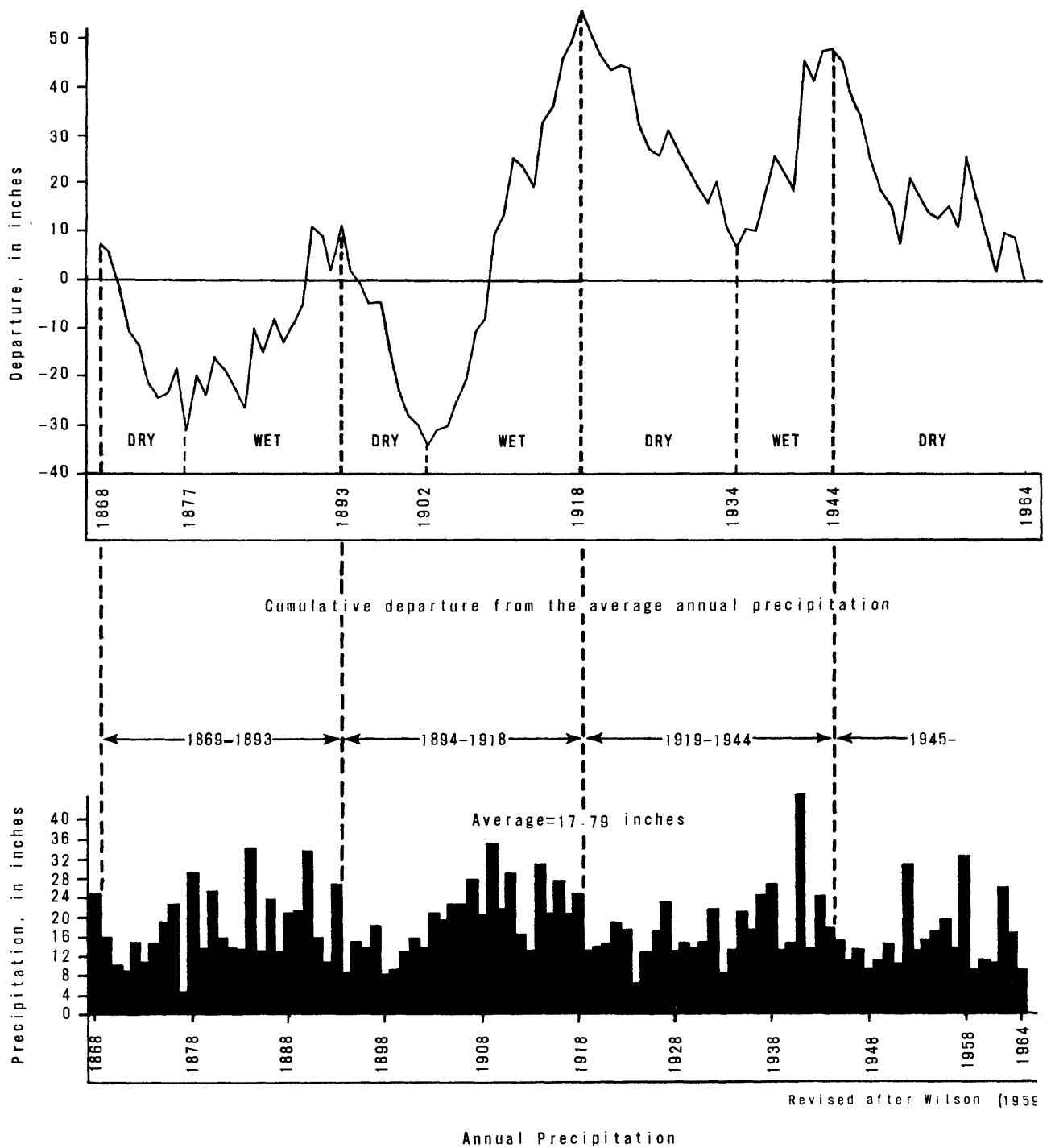
FIGURE 5.--Precipitation at Santa Barbara, showing cumulative departure
from the average for the period 1868-1964.

TABLE 1.--*Annual precipitation, in inches, measured at Santa Barbara and at four stations in the Santa Ynez upland basin during the period 1946-64*

| Year ending Sept. 30 | Santa Barbara | Santa Ynez upland | | | |
|---|---|---|---|---|---|
| | | Marre Ranch | Zaca-San Antonio divide | Zaca-Foxen divide | Santa Ynez |
| 1946 | 11.33 | 10.89 | 13.67 | 13.49 | a12.1 |
| 1947 | 13.41 | 9.76 | 11.31 | 11.30 | a10.6 |
| 1948 | 9.20 | 7.46 | b6.0 | 9.32 | 28.5 |
| 1949 | 10.95 | 9.95 | 12.52 | 10.18 | 10.06 |
| 1950 | 14.40 | 10.96 | 15.37 | 14.39 | 10.62 |
| 1951 | 10.06 | b11.8 | 10.89 | 10.89 | 8.82 |
| 1952 | 31.25 | 20.99 | 22.69 | 24.35 | 24.51 |
| 1953 | 13.37 | 10.98 | 12.73 | b14.6 | 10.52 |
| 1954 | 15.45 | 13.82 | 11.96 | b11.5 | 10.63 |
| 1955 | 16.37 | 12.16 | 15.44 | 14.72 | 11.31 |
| 1956 | 19.83 | 17.63 | 17.51 | b17.6 | 12.64 |
| 1957 | 13.86 | 11.30 | b12.3 | 12.09 | 9.99 |
| 1958 | 32.31 | 31.30 | 28.04 | 28.99 | 27.91 |
| 1959 | 8.80 | 11.19 | 8.49 | 9.06 | 10.60 |
| 1960 | 10.81 | 10.88 | 12.75 | 13.36 | 10.12 |
| 1961 | 10.04 | 9.67 | 8.52 | 7.53 | 7.14 |
| 1962 | 26.13 | 20.54 | 24.90 | 23.22 | 18.67 |
| 1963 | 16.71 | 14.73 | 15.04 | 15.09 | 13.52 |
| 1964 | 9.11 | 10.66 | 9.92 | 10.50 | 7.89 |
| Average: | 15.44 | 13.51 | 14.21 | 14.32 | 12.43 |

a. No local records available. Estimate based on unofficial measurements made 2 miles west of Santa Ynez by local resident.
b. Estimate based upon incomplete monthly rainfall records.

The higher average annual rainfall at the Santa Barbara station may be attributed largely to the effect of the Santa Ynez Mountains and the eastward narrowing of the Santa Ynez valley. Air masses moving northward over the Santa Ynez Mountains drop considerably more moisture on the higher slopes than on the basal slopes of the range. Similarly, rainfall is greater in the San Rafael Mountains than in the lower elevations of the Santa Ynez upland ground-water basin. Studies by the U.S. Corps of Engineers (reported in Upson and Thomasson, 1951, p. 8) concluded that the average annual precipitation is from 28 to 30 inches along the crest of the San Rafael Mountains just north of the Santa Ynez upland ground-water basin. This results in a large stream runoff, particularly to the eastern part of the upland area where Santa Cruz Creek flows across the ground-water basin.

The San Rafael and Santa Ynez Mountains exert a major local influence on winter storms which usually come from the west or the northwest. As a result, precipitation may vary greatly at different stations during individual storms. However, the total annual precipitation for any given year at the Santa Ynez upland stations, as related to that at Santa Barbara, is of about the same general magnitude. Therefore, the long-term variations in precipitation, the wet and dry periods illustrated in figure 5, probably occur rather uniformly over a large area which includes the upland and Santa Barbara stations.

Although years of exceptionally high or low rainfall may occur at any time, the graph of annual precipitation at Santa Barbara and the cumulative-departure curve show that years of above-average and below-average rainfall tend to be clustered, indicating a fluctuation in precipitation which has produced three complete periods of alternating dry and wet years averaging about 25 years' duration each from 1869 through 1944. However, on the basis of interpretation of the 97 years of rainfall record for Santa Barbara, the periods are by no means cyclical, particularly in the more recent parts of the record. The three dry-wet periods of 1869-93, 1894-1918, and 1919-44 are readily apparent in figure 5. Interpreting the more recent data in the same way, 1945-64 might be considered to be the dry part of a fourth dry-wet period of unknown duration. However, the dry part of such a period has been at least 19 years long.

## Surface Water

Most of the precipitation which falls on the land surface of an arid or semiarid region is returned to the atmosphere by evaporation or transpiration. The rest either infiltrates to the water table or flows on the land surface as runoff. That part of the precipitation which becomes runoff is determined by the nature of the topography and geology, the type and density of vegetative cover, soil conditions, and the nature and distribution of storms in an area.

Most of the runoff which flows out of the Santa Ynez upland ground-water basin originates in the drainage area lying between the ground-water basin and the crestline of the San Rafael Mountains. Along this flank of the San Rafael Mountains steep slopes and increased rainfall at higher elevations cause a higher rate of runoff than in the foothills. Of the 134-square-mile area along the south flank of the San Rafael Mountains draining into the ground-water basin, the drainage area of Santa Cruz Creek is by far the largest. This drainage area covers about 65 square miles north of the fault boundary and supplies at least 60 percent of the total surface flow into the Santa Ynez upland ground-water basin.

Gaging stations have been maintained by the U.S. Geological Survey for varying periods along the lower reaches of Santa Cruz, Cachuma, Santa Agueda, Zanja de Cota, and Alamo Pintado Creeks (fig. 2). Annual total flow at these stations is shown in table 2. Where records were incomplete totals in acre-feet were estimated from available monthly totals and daily measurements.

The perennial flow in Zanja de Cota, Santa Cruz (at the lower station, 1946-52), Alamo Pintado, and Santa Agueda Creeks is the result of the discharge of ground water at springs along the consolidated-rock barrier at the south boundary of the ground-water basin. Ground-water discharge across this barrier is discussed in the section on the hydrologic inventory. Upstream from the barrier, Santa Cruz, Alamo Pintado, and Santa Agueda Creeks are usually dry from June or July until December.

TABLE 2.--*Surface-water outflow, in acre-feet, from the Santa Ynez upland ground-water basin, 1946-64*

| Water year ending Sept. 30 | Santa Cruz Creek near Santa Ynez | Cachuma Creek near Santa Ynez | Zanja de Cota Creek near Santa Ynez | Alamo Pintado Creek near Solvang | Santa Agueda Creek near Santa Ynez |
|---|---|---|---|---|---|
| 1946 | 6,600 | -- | -- | -- | 1,140 |
| 1947 | 3,580 | -- | -- | -- | 558 |
| 1948 | 346 | -- | -- | -- | 133 |
| 1949 | 1,630 | -- | -- | -- | 142 |
| 1950 | 2,700 | -- | -- | -- | 160 |
| 1951 | 340 | 274 | -- | -- | 116 |
| 1952 | 29,500 | 8,800 | -- | -- | 6,380 |
| 1953 | a4,250 | 1,080 | -- | -- | 516 |
| 1954 | 5,440 | 995 | -- | -- | 376 |
| 1955 | 1,890 | 485 | 1,360 | -- | 150 |
| 1956 | 9,410 | 1,750 | 1,380 | -- | 1,200 |
| 1957 | 2,100 | 357 | 965 | -- | 172 |
| 1958 | 43,720 | 11,660 | 3,090 | -- | 10,690 |
| 1959 | b3,880 | 922 | 1,460 | -- | 317 |
| 1960 | 1,640 | 398 | 905 | -- | 30 |
| 1961 | 167 | 167 | 663 | -- | 91 |
| 1962 | 20,510 | 5,040 | -- | -- | 3,900 |
| 1963 | 2,240 | -- | -- | -- | 44 |
| 1964 | 665 | -- | -- | -- | 0 |
| Total: | 141,000 | c35,000 | c35,000 | c9,500 | 26,100 |

a. Gaging station moved 1.7 miles upstream.
b. Gaging station moved 0.6 mile downstream from Pine Canyon.
c. Total runoff for 1946-64 estimated on basis of available records and comparison with flows in Santa Cruz and Santa Agueda Creeks.

## Ground Water

Ground water in the Santa Ynez upland and adjoining area is stored in the unconsolidated deposits. These deposits fill a basin formed by a series of synclinal depressions bounded by faults and by non-water-bearing rocks. To determine the storage capacity and the quantity of ground water in storage in this basin, the basin boundaries must be delineated and the volume and specific yield of the water-bearing sediments must be estimated. To calculate the perennial yield of the basin, the path of ground-water movement must be delineated and water-level fluctuations in relation to the inflow and outflow of ground water must be analyzed.

## Boundaries of the Ground-Water Basin

The Santa Ynez upland ground-water basin is a 130-square-mile wedge-shaped structural basin which has a northwest trend (figs. 2 and 3). The north and northeast boundaries of the ground-water basin are formed by a complex of northwest-trending reverse faults. The complex extends from the south flank of Loma Alta near Redrock Canyon on the east to several miles beyond the upper reaches of Sycamore Canyon. The northwest boundary is a ground-water divide near the Zaca Oilfield, which is approximately congruent with the drainage divide between Zaca Creek and San Antonio Creek. Between the south end of the drainage divide, at the northeast flank of the Purisima Hills, and Zaca Creek the boundary is the upturned base of the Careaga Sand.

The southwest boundary, between Zaca Creek and Alamo Pintado Creek (Ballard Canyon area), is not well defined. Extensive soil cover, indistinct bedding in the Careaga Sand, and a scattered blanket of terrace gravel obscure the geologic structure. Geologic mapping by Dibblee (1950) indicated that consolidated Tertiary rocks underlie the Purisima Hills in the upper reaches of Ballard Canyon; thus ground-water movement toward the south is blocked.

Where the Careaga Sand is sufficiently thick it probably is a route for ground water to move across the more intensely deformed underlying rocks. Some of the water discharging from the main ground-water basin in this area would recharge the alluvial deposits in Ballard Canyon, while some probably passes through fractured zones in the consolidated rocks and discharges into the alluvium in the Santa Ynez River valley between Buellton and Solvang. Sufficient hydrologic data are not available to prove these suppositions. However, the water levels in wells 6N/31W-4A1 and 7N/31W-34M1 in Ballard Canyon suggest that in this area the general ground-water level is several tens of feet lower in elevation than that along Alamo Pintado Creek directly to the east.

The boundary of the ground-water basin in the area between Alamo Pintado and Santa Agueda Creeks is covered by terrace gravel and is not well defined. However, the existence of a ground-water barrier is indicated by an extensive area of phreatophytes in the alluvium of Zanja de Cota Creek and by a spring in the town of Santa Ynez. Upson (Upson and Thomasson, 1951) suggested that ground water which discharges into Zanja de Cota Creek may have risen along a fault in that area. However, the senior author could find no direct evidence for such a fault. Mapping by Dibblee (1950) and field checking by the senior author suggest that the basin boundary in this area is the terrace-covered consolidated Tertiary rocks.

Much of the south boundary of the basin east of Santa Agueda Creek is clearly marked by outcrops of steeply dipping consolidated Tertiary rocks.

The east boundary of the ground-water basin is clearly delineated by the base of the Careaga Sand which crops out along the Redrock Canyon.


Occurrence and Movement


Upson (Upson and Thomasson, 1951, p. 101-102) demonstrated the existence of three distinct water bodies in the Santa Ynez upland. They consist of the main water body in the Paso Robles Formation, a shallow semiperched water body in the Paso Robles Formation on the west side of the terraced upland, and a confined water body in the Careaga Sand.

The Paso Robles Formation is the most important aquifer of the Santa Ynez upland basin. It underlies almost the entire ground-water basin and its volume is three times that of the Careaga Sand, terrace deposits, and alluvium combined. Water stored in this formation is of greater importance than water stored in the Careaga Sand because, except near the basin margins, water in the Careaga Sand lies beneath a considerable thickness of the Paso Robles Formation, and generally is at a lower head than water in the Paso Robles Formation. Future development of ground water in the Santa Ynez upland basin will, therefore, be primarily dependent on water available within the Paso Robles Formation.

Artesian conditions may exist in the Paso Robles Formation where steeply dipping strata of gravel and sand crop out in high catchment areas and are confined or partially confined by less permeable beds of silt and clay. Such conditions occur most ideally just south of the fault zone which forms the north boundary of the basin and along the northeast flank of the Purisima Hills. Pumping of ground water in the basin has sufficiently reduced the artesian head in many areas of confined water so that the water level in many previously flowing artesian wells is now many feet or even tens of feet below the land surface. This has occurred in wells in Happy Canyon (7N/29W-32M1) and along Alamo Pintado Creek (7N/31W-23P1).

Bodies of shallow perched water occur in the Paso Robles Formation in Marre Canyon (7N/30W-24Q1) and to the east of Happy Canyon (6N/29W-5A1).

Ground water in the Santa Ynez upland basin moves readily through the alluvium which fills the stream valleys. Where the valleys are narrow and the cross-sectional area of alluvial fill is decreased, water may be forced to the surface to move as intermittent or perennial flow in the stream channels. Such narrowing occurs where stream channels have cut through the consolidated rocks which form the south boundary of the basin. This causes perennial flow in Zanja de Cota, Alamo Pintado, Santa Agueda, Zaca, and Santa Cruz Creeks. All other ground water which discharges naturally from the basin is either transpired by plants or discharged as underflow through thin, narrow strands of alluvium which line the valleys tributary to the Santa Ynez River. The distribution and quantity of this subsurface flow are discussed under the hydrologic inventory.

The water-level contours (fig. 3), constructed by connecting points of equal elevation of the water table within the Paso Robles Formation using water-level measurements made in December 1964, show the direction of ground-water movement. The conformity of the water-level contours indicates that, in general, the Paso Robles Formation may be considered as a single stroage unit, although there are areas of partial confinement and local bodies of perched water within the formation.

The most striking features of the December 1964 water-level-contour map are: (1) The general slope of the water table to the southwest over the northern two-thirds of the basin, and (2) the area of low water-table gradients underlying the central area of the upland.

The water table in the south part of the basin has an average gradient of about 100 feet per mile.  In the north part of the basin the gradient steepens to 200 to 250 feet per mile, but in the central area of the upland, north and northeast of the town of Santa Ynez, gradients are only 15 to 50 feet per mile.  Ground water moves toward the upland from the north, northwest, northeast, and east, and is discharged either by pumping or as surface flow from springs rising chiefly near Zanja de Cota Creek.  The contours also indicate that ground water discharges into the alluvium of Alamo Pintado, Santa Cruz, and Horse Creeks.

Where the contours are concave downstream, water is discharging into the stream alluvium from the Paso Robles Formation.  The only exception to this condition in the ground-water basin is in the lower part of Happy Canyon where the water-level contours are convex downstream, which means that underflow or surface flow in Happy Creek is discharging to the deep water body in the Paso Robles Formation.


Water-Level Fluctuations


The various hydrologic parameters, such as increased recharge which act upon a water body, cause physical changes within the body.  These changes are usually reflected by the water level or artesian pressures within the water body and can be recognized in a hydrograph of long-term water-level fluctuations.  Figure 6 shows six such hydrographs.  All six hydrographs show a general decline during the periods of record.

The two wells 6N/30W-6A1 and 7N/30W-33M2 nearest the main center of pumpage show marked seasonal fluctuation along with a rather steady annual decline.  These wells tap the main water body in the Paso Robles Formation, and the hydrographs reflect the heavy pumpage from that body.  They do not show any noticeable recharge following periods of above-average rainfall.

Wells 7N/31W-23P1 and 6N/30W-3A1 also show seasonal fluctuations, but they are somewhat erratic in amplitude.  This fluctuation may be caused mainly by annual weather changes rather than by annual pumpage cycles.  That these wells are affected by changes in annual precipitation is evidenced by the strong recovery in 1952, 1958, and 1962.  Well 7N/31W-23P1 is perforated in the alluvium, but 6N/30W-3A1 is perforated from 80 to 407 feet, entirely in the Paso Robles Formation.  The greater response to recharge shown by 7N/31W-23P1 is indicative of the higher permeability of the alluvium, while the response shown by 6N/30W-3A1 shows that the alluvium of the stream valley transmits recharge to the main water body.  Wells farther than $1\frac{1}{2}$ miles from the stream valleys do not show this response.
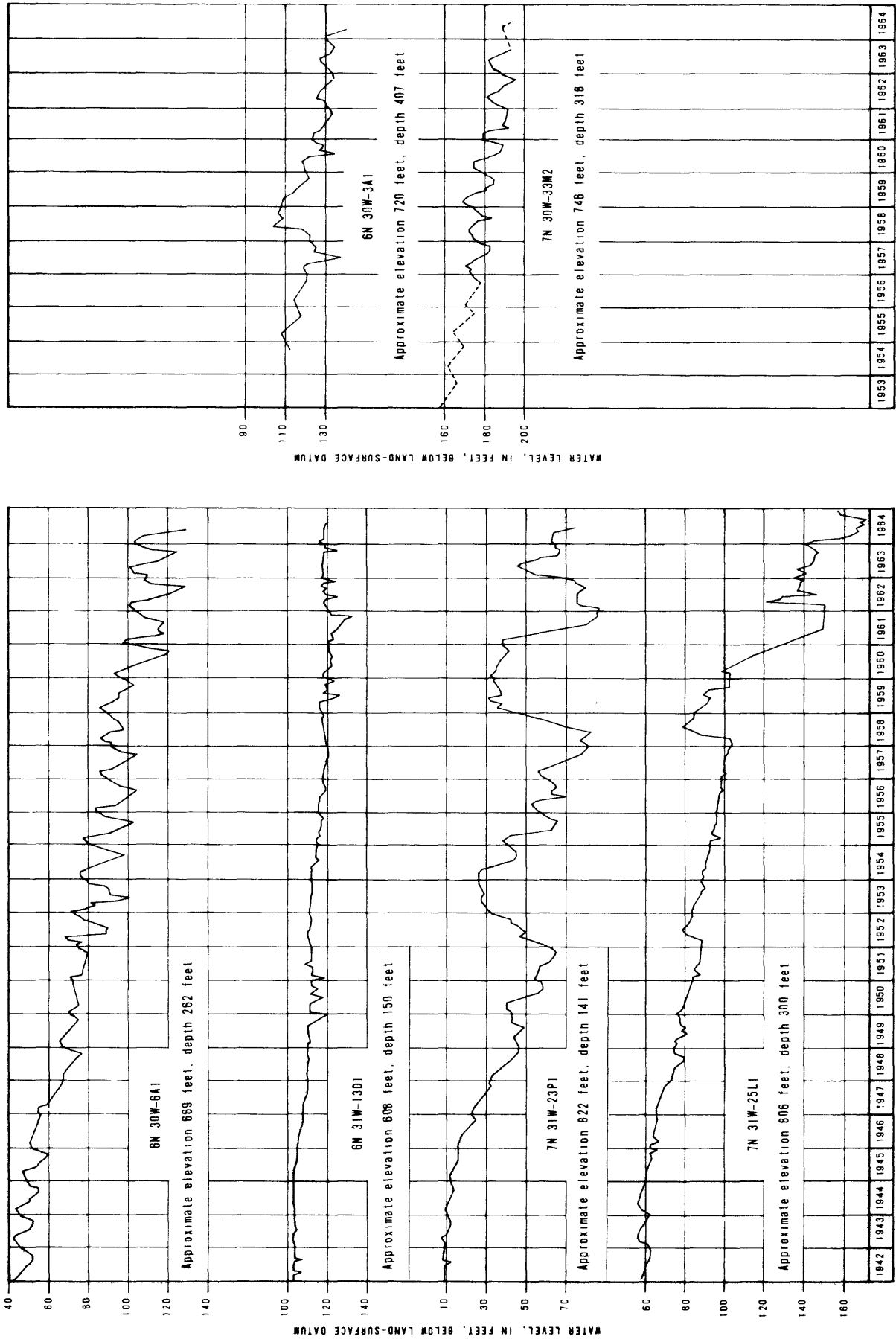
FIGURE 6.—Hydrographs of six wells in the Santa Ynez upland ground-water basin.

Before it was deepened in August 1960 well 7N/31W-25L1 apparently tapped the shallow, semiperched water body on the west side of the terraced upland.  The hydrograph for the period prior to 1960 does not show seasonal fluctuations as do 6N/30W-6A1 and 7N/30W-33M2, but it does show recovery following periods of above-average rainfall in 1952 and 1958.  When the well was deepened from 226 feet to 300 feet, the water level dropped rather rapidly probably due to a lower head in the deeper water body.  The recovery which followed the period of above-average rainfall in 1962 and the subsequent decline appear to indicate that this well reflects both the shallow semiperched water body and the main water body.

The water level in well 6N/31W-13D1 has remained almost unchanged during the period 1956-64, indicating that recharge of ground water to this area is not greatly affected by a single season of high rainfall.  A steady flow of ground water rising from the Careaga Sand is probably the reason water levels have not fluctuated or declined rapidly in this area.

## Storage Capacity

The quantity of ground water stored in the Santa Ynez upland ground-water basin is a product of the volume of saturated sediments contained in the basin and the specific yield[1] of the sediments.

The average basin-wide thickness of the Paso Robles Formation and of the Careaga Sand as indicated by wildcat oil-test well data is 1,500 feet for the Paso Robles Formation and 500 feet for the Careaga Sand. Unconsolidated deposits within the approximately 130-square-mile basin, therefore, average about 2,000 feet in total thickness.  The volume of this prism-shaped mass of sediments is about 50 cubic miles.  Taking into account known depths to water which average about 200 feet below land surface for the basin as a whole, the maximum area-wide average thickness of saturated unconsolidated deposits in the basin is about 1,800 feet. This would constitute a volume of more than 140 million acre-feet of saturated sediments.

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[1]The specific yield of a rock or soil, with respect to water, is the ratio of (1) the volume of water which, after being saturated, it will yield by gravity to (2) its own volume.

Specific yield of the uppermost 100 feet of saturated sediments, which include alluvial and terrace deposits, and strata of the upper part of the Paso Robles Formation, was calculated from well-log data to be 7½ percent.

Electric logs and lithologic logs from deep water wells and oil wells are too few to permit detailed calculation of basin-wide specific-yield averages for the Paso Robles Formation and the Careaga Sand. The scant data suggest that the average specific-yield value for the entire 1,800 feet thickness of saturated sediments found in the ground-water basin is about equal to that of the first 100 feet--7½ percent.

The approximate volume of saturated sediments, equal to about 140 million acre-feet, with an average specific yield of 7½ percent, indicates a total storage capacity of about 10 million acre-feet. Under present conditions, ground water can be pumped economically from only about the upper 200 feet of saturated sediments. Therefore, usable ground water in storage in the Santa Ynez upland ground-water basin is presently about 1 million acre-feet.

## Changes in Ground-Water Storage

Changes in the quantity of ground water in storage were estimated by a comparison of the water-level change for the period 1945-64. The net water-level change in the central part of the Santa Ynez upland ground-water basin for the period was derived by superimposing water-level-contour maps for April 1945 and April 1964 (maps not shown).

The change in the amount of ground water in storage in the central part of the basin was calculated by multiplying the affected areas of water-level change (changes of 25, 50, and 100 feet) by the respective average water-level changes and the average specific yield of 7½ percent.

*Estimated change in ground-water storage in central part of Santa Ynez upland ground-water basin, April 1945-April 1964*

| Area (acres) | Water-level decline (feet) | Specific yield (percent) | Change in storage (acre-feet) |
|---|---|---|---|
| 1,000 | 100 | 7.5 | 7,500 |
| 5,900 | 50 | 7.5 | 22,000 |
| 7,700 | 25 | 7.5 | 14,400 |
| Total change in storage: | | | 44,000 |

The net reduction of the amount of ground water in storage for the period 1945-64 is 44,000 acre-feet. This represents the quantity of water removed from storage beneath the area of heavy irrigation in the upland during this 19-year period.

Very little data are available concerning water-level changes in the more than 100 square miles of the basin outside of the central part of the upland. The few scattered long-term water-level records available for this area suggest that the average basin-wide decline (outside the irrigated upland area) did not exceed 3 feet for the 1945-64 period. Assuming an average specific yield of 7½ percent, an average 3-foot water-level decline would result in a storage change of about 15,000 acre-feet, or one-third as much water as has been removed from beneath the much smaller upland area.

For the entire basin, then, a total maximum decrease of ground water in storage of about 60,000 acre-feet is estimated for the period 1945-64.

## The Hydrologic Inventory

Circulation of the earth's waters between oceans, atmosphere, and continents constitutes the system known as the hydrologic cycle. Most of the water in a ground-water basin originates as precipitation directly upon the basin or as surface or subsurface flow resulting from precipitation outside the basin. In the Santa Ynez upland ground-water basin, geologic barriers with very low permeabilities probably limit subsurface inflow and outflow to a negligible quantity. Therefore, flow into and out of the ground-water basin is dependent on precipitation, surface flow, pumpage within and adjacent to the basin, and on the effects of vegetation and geology. These parameters form the basis for the hydrologic inventory which may be expressed as follows: Ground-water recharge minus ground-water discharge equals change in quantity of ground water in storage. Items of discharge include surface and subsurface outflow, evapotranspiration, and water pumped for irrigation and other uses. Items of recharge include infiltration of precipitation, seepage losses from streams, subsurface inflow, and return irrigation water.

Ground-Water Discharge


Subsurface outflow.--Ground-water flow out of the Santa Ynez upland ground-water basin is probably quite small. Along most of the south margin of the basin consolidated rocks act as an impermeable barrier to the subsurface movement of ground water. A very small quantity of water may discharge from the basin through fractures in chert in the consolidated rock of the Ballard Canyon area.

Most of the subsurface outflow from the ground-water basin occurs in the alluvial fill of the stream valleys which cross the consolidated rock barrier. However, this quantity is probably small in comparison with the quantity of ground water discharging as surface outflow, so it is not considered quantitatively in the hydrologic budget.

Surface outflow.--Most of the natural discharge of ground water from the Santa Ynez upland basin occurs as surface flow in Zanja de Cota Creek. Rising ground water north of the consolidated rock barrier flows into the channel of Zanja de Cota Creek from springs and discharges southward into the Santa Ynez River through the channel cut in the barrier. The same situation exists where Zaca, Alamo Pintado, Santa Agueda, and Santa Cruz Creeks cross the consolidated rocks before joining the Santa Ynez River. The combined ground-water discharge from the basin into these four streams is usually much less than that into Zanja de Cota Creek. From June or July until December the total flow at the barrier in Santa Cruz, Alamo Pintado, and Santa Agueda Creeks consists of base flow.

Estimates of the annual outflow from the Santa Ynez upland ground-water basin are given in table 3. Most of the data to about 1961 are based on streamflow records published in Geological Survey water-supply papers. After 1961, measurements had been discontinued on all but Santa Cruz and Santa Agueda Creeks, so the quantity of ground water discharged as surface flow for the period 1960-64 is only an approximation.

TABLE 3.--*Estimated ground-water discharge in acre-feet, into creeks in the Santa Ynez upland basin for the period 1946-64*

| Water year ending Sept. 30 | Santa Cruz | Zanja de Cota | Alamo Pintado | Santa Agueda | Zaca | Total |
|---|---|---|---|---|---|---|
| 1946 | 600 | 4,000 | 500 | 500 | a200 | 5,800 |
| 1947 | 500 | 2,700 | 375 | 250 | 200 | 4,100 |
| 1948 | 350 | 2,700 | 160 | 125 | 200 | 3,600 |
| 1949 | 500 | 2,340 | 150 | 90 | 200 | 3,300 |
| 1950 | 500 | 2,340 | 130 | 60 | 200 | 3,300 |
| 1951 | b350 | 2,340 | 120 | 0 | 200 | 3,000 |
| 1952 | 600 | 2,760 | 100 | 0 | 200 | 3,700 |
| 1953 | 500 | 2,520 | 120 | 100 | 200 | 3,500 |
| 1954 | 500 | 2,000 | 50 | 30 | 200 | 2,800 |
| 1955 | 500 | 1,750 | c50 | 30 | 200 | 2,600 |
| 1956 | 500 | 1,400 | 50 | 120 | 200 | 2,300 |
| 1957 | 500 | 1,100 | 50 | 120 | 200 | 2,000 |
| 1958 | 500 | 1,200 | 50 | 120 | 200 | 2,100 |
| 1959 | 500 | 1,600 | 50 | 35 | 200 | 2,400 |
| 1960 | 500 | 900 | 50 | 0 | 200 | 1,700 |
| 1961 | 450 | 1,000 | 50 | 0 | 200 | 1,700 |
| 1962 | 450 | c1,000 | 50 | 0 | 200 | 1,700 |
| 1963 | 450 | 1,000 | 50 | 0 | 200 | 1,700 |
| 1964 | 450 | 1,000 | 50 | 0 | 200 | 1,700 |

Total estimated ground-water discharge:                    53,000

a.  No total annual flow measurements available for this stream. Discharge values are therefore only approximations.

b.  Gaging station moved 1.7 miles upstream which placed it above point where ground-water inflow occurs.  Therefore, this and subsequent annual discharge figures are only approximations.

c.  Measurements discontinued at this station; this and subsequent annual discharge figures for this creek are only approximations.

The total ground-water discharge from the Santa Ynez upland basin as surface flow for the period 1946-64 is about 53,000 acre-feet. Table 3 shows a decrease in annual discharge of ground water during the period 1946-50 of from 5,800 to 3,300 acre-feet per year. During this period, ground-water discharge to streams averaged about 4,000 acre-feet per year. From 1950 to 1960, the average dropped to 2,600 acre-feet per year. For the early 1960's it is about 1,700 acre-feet per year.

Evapotranspiration.--Phreatophytes are plants which take their water from below the water table or from the capillary fringe. There are only a few heavy concentrations of phreatophytes along the creeks which drain the Santa Ynez upland basin. In the western part of the basin much of the area bordering Santa Agueda and Alamo Pintado Creeks is grazing land or irrigated land.

Along Zanja de Cota Creek, phreatophytes are abundant downstream from the area of rising ground water. Although most of these phreatophytes, chiefly willows, are south of the basin boundary, they consume ground water along the reaches of the stream above the gaging station near the junction of Zanja de Cota Creek and the Santa Ynez River. Surface flow measured at this gaging station usually increases in October and November when evapotranspiration rates decrease. Approximately 70 acres of phreatophytes along Zanja de Cota Creek use an estimated several hundred acre-feet of water per year.

In the eastern part of the basin there is only minor phreatophyte development along Cachuma, Santa Cruz, and Horse Creeks and the creek that drains Happy Canyon. The phreatophytes consist chiefly of scattered small groves of sycamores and a few stands of willows. Most of the vegetative cover on the alluvium of these creeks consists of chaparral, grass, and Digger pine, live oak, and black oak. These plants are not classed as phreatophytes.

The water consumed by the phreatophytes along the creeks of the Santa Ynez upland basin is estimated to be not more than 1,000 acre-feet per year.

Pumpage.--Pumpage for irrigation for the period 1935-44 (table 4) in
the Santa Ynez upland was estimated by Upson and Thomasson (1951, p. 104).
Their estimates were based on the average amount of electrical energy
required to pump 1 acre-foot of water and the total amount of electricity
used by irrigation wells on the upland during the irrigation season.  The
amount of electrical energy consumed by irrigation pumping each season was
obtained from the Pacific Gas and Electric Co.  As shown in table 4, total
ground-water withdrawals to 1944 averaged about 614 acre-feet per year.

TABLE 4.--*Water pumped from wells in the Santa Ynez upland ground-water
basin, 1935-44*

| Year | Acre-feet | | Year | Acre-feet |
|------|-----------|---|------|-----------|
| 1935 | 590 | | 1940 | 420 |
| 1936 | 580 | | 1941 | 430 |
| 1937 | 400 | | 1942 | 690 |
| 1938 | 420 | | 1943 | 830 |
| 1939 | 400 | | 1944 | 1,380 |
| | | | 10-year average: | 614 |

Pumpage for the period 1946-64 was also computed from power
consumption, by the method discussed previously.  However, since the 1946-64
period was one of declining water levels, a yearly adjustment of the amount
of electrical energy used to pump 1 acre-foot of water was made to reflect
the increases in total pumping lift.  Water-level fluctuations in 11 wells,
considered to be typical of the irrigated upland area, were averaged to
calculate year-to-year water-level changes.  The average changes for the
years 1946-64 were used to calculate annual energy factors.  During the
19-year  period, the mean energy input per acre-foot of water delivered to
the land surface has increased from about 305 kilowatthours to
460 kilowatthours.  This is an average increase of about 50 percent.  The
increase is not as great outside the upland where water levels have declined
more slowly.

Total annual pumpage estimates for the entire ground-water basin, adjusted for the increased energy input described above, are shown in table 5. These pumpage totals include water pumped for domestic and stock use by the Santa Ynez River Water Conservation District and by the Solvang Municipal Improvement District. The quantity of water pumped for domestic, industrial, and stock use amounted only to several hundred acre-feet per year in recent years and is quite small in comparison to pumpage for irrigation. The quantity of water permanently removed from storage is less than that pumped because about 20 percent of the water used for irrigation returns to the ground-water reservoir by percolation downward to the water table.

TABLE 5.--*Water pumped from wells in the Santa Ynez upland ground-water basin, 1946-64*

| Year beginning May 1 | Acre-feet | Year beginning May 1 | Acre-feet |
|---|---|---|---|
| 1946 | 4,500 | 1956 | a7,300 |
| 1947 | 4,500 | 1957 | 7,900 |
| 1948 | 4,900 | 1958 | 9,400 |
| 1949 | 6,200 | 1959 | 12,300 |
| 1950 | 5,400 | 1960 | 12,800 |
| 1951 | 4,500 | 1961 | 10,700 |
| 1952 | 6,200 | 1962 | 10,700 |
| 1953 | 5,200 | 1963 | 8,900 |
| 1954 | 6,800 | 1964 | 11,300 |
| 1955 | 6,800 | | |
| | | Total for 1946-64: | 146,300 |
| | | Average for 1946-64 period: | 7,700 |

a. Estimated.

Total ground-water discharge.--The total ground-water discharge from
the Santa Ynez upland basin is the sum of ground water discharged as surface
outflow, evapotranspiration, and pumpage.  The estimated total discharge
for the period 1946-64 is 218,000 acre-feet.  As in most ground-water basins
in southern California, a general increase in total annual ground-water
discharge over the 19-year period has occurred.  Since 1960 the total
discharge has averaged more than 13,000 acre-feet per year.


Ground-Water Recharge


The major sources of recharge or inflow to the ground-water basin are
infiltration of rain, return of irrigation water, and seepage from streams.
These and other sources of recharge are discussed in the following sections.

Infiltration of rain.--Most of the rain that falls in the Santa Ynez
upland basin is consumed by evapotranspiration.  However, during periods of
heavy rainfall some rainwater penetrates below the root zone of the
vegetation and eventually reaches the water table as recharge.  The quantity
of rainwater that infiltrates to the water table is extremely difficult to
estimate because it varies with the rainfall intensity, permeability and
moisture content of the soil, type of vegetation, and the slope and
irregularity of the surface.

Field studies of infiltration or deep penetration of rainfall over a
5-year period were made in neighboring Ventura County by Blaney (1933).
Climatic, topographic, and vegetative-cover conditions in the areas studied
by Blaney are comparable to those in the Santa Ynez upland basin.  Using
Blaney's data (1933, table 57) a graph was constructed that related seasonal
rainfall to the deep penetration of rain that would occur on the three major
divisions of vegetative cover that occur in the Santa Ynez upland basin,
namely, 1.  brush, 2.  grass and weeds, and 3.  truck garden and alfalfa.
The acreage covered by the different vegetative types was taken from
U.S. Department of Agriculture vegetation maps.  The results indicate that
for land covered by grass and weeds 18 inches of precipitation are required
before deep penetration will occur and for land covered by brush 21 inches
of precipitation are required.  Moreover, these data indicate that the
total infiltration of rainfall in the Santa Ynez upland basin for the
period 1946-64 is about 70,000 acre-feet or about 3,700 acre-feet per year
(an average of slightly less than 0.6 inch per acre per year).

Return of irrigation water.--Water which is pumped from a ground-water reservoir for irrigation is, in part, consumed by the plants; in part, runs off the surface to discharge in creeks; and, in part, is lost by evaporation and transpiration; the remainder percolates downward to the water table. Estimates of the amount of irrigation water which returns to ground-water storage in different areas in the Santa Ynez River basin were made by Upson and Thomasson (1951, p. 125). Their studies suggest that about 20 percent of the amount of water applied for irrigation returns to ground-water storage. The total pumpage for the Santa Ynez upland basin for the period 1946-64 amounts to 146,300 acre-feet. This includes a small quantity of water pumped for domestic use. The total recharge to the ground-water basin by infiltration of irrigation water, therefore, amounts to about 29,300 acre-feet for the 1946-64 period, or an average of about 1,500 acre-feet per year.

Seepage loss.--The quantity of water which percolates to the water table by seepage from a stream in any area is normally evaluated on the basis of decreased streamflow between two gaging stations. However, none of the streams which traverse the Santa Ynez upland ground-water basin is gaged at two sites, so no measurement of seepage losses could be made. An approximation of the seepage losses of streams for 1946-64 can be obtained by subtracting the sum of the estimated infiltration of rain, return of irrigation water, and change in ground-water storage for this period (see p. 39) from the estimated total ground-water outflow. Stream seepage loss estimated in this way is 59,000 acre-feet for the 19-year period.

The hydrographs of wells located near Alamo Pintado and Santa Agueda Creeks (fig. 6) show that water levels recover rapidly near streams during years of above-average rainfall. The high water levels in these areas are maintained for about 2 years following a wet year, and are undoubtedly caused by discharge of ground water to the stream alluvium from the Paso Robles Formation.

Underflow.--Very little data are available for evaluating ground-water underflow into the Santa Ynez upland basin. The reverse faults which make up the north and northeast basin boundary act as an effective barrier to ground-water movement between the consolidated sediments which form the foothills. Ground water accumulating in fractures in the consolidated rocks flows over the fault barrier forming springs. Water from springs of this type flows over the fault zone in the vicinity of Loma Alta (secs. 20 and 28, T. 6 N., R. 28 W.) and Birbent Canyon (sec. 29, T. 8 N., R. 30 W.). Ground water also probably seeps over the fault barrier as underflow through the mantle of soil which overlies the fault zone along much of its length.

Most of the ground water which enters the basin from the consolidated rocks occurs as underflow in the alluvium of creeks which cross the fault barrier where the canyons intersect the water table in the consolidated rocks.  Narrow tongues of alluvium overlie the fault barrier in the canyons of Horse, Santa Cruz, and Cachuma Creeks, but in the western part of the basin, the alluvial fill in the valleys is absent just south of the fault. Because all the creeks are dry during the summer and fall, underflow into the ground-water basin at that time is limited to water which can move through the narrow sections of alluvial fill in the creeks mentioned above. This quantity is thought to be quite small and is, therefore, not considered in the hydrologic inventory.

Wilson (1959, p. 56) suggested the possibility of recharge to the Santa Ynez upland ground-water basin from Lake Cachuma.  When full, the lake surface is at an elevation of 750 feet above sea level and inundates about a mile-long section of the Careaga Sand and Paso Robles Formation in Santa Cruz and Cachuma Canyons, and about a half-mile-long section of the unconsolidated deposits in Johnson Canyon.  The outcrops of Careaga Sand are 150 to 200 feet thick in the canyons inundated by the reservoir.  However, the outcrops of Careaga Sand pinch out about half a mile west of Johnson Canyon and reappear a mile farther west (fig. 3).

Logs of wildcat oil-test wells indicate that the Careaga Sand is continuous at depth to the north, which means that ground water in the Careaga Sand beneath Lake Cachuma could be hydraulically connected to ground water in the Careaga Sand to the west.  However, lithologic changes in the formation might isolate ground water near the reservoir from ground water in the western part of the basin.

No wells have been drilled to the Careaga Sand in the area between Lake Cachuma and the central area of the upland, so no evidence is available to show if Lake Cachuma has had an effect on the head of water in the Careaga Sand.  Head changes occurred in the Careaga Sand near Lake Cachuma when the lake was initially filled as a result of the above-average rainfall of 1958, but it would require several deep test wells and years of water-level measurements to quantitatively evaluate recharge through the Careaga Sand to the Santa Ynez upland from the lake.

A 2,000-foot section of the Paso Robles Formation is inundated in Santa Cruz and Cachuma Canyons when Lake Cachuma is filled to capacity. About 1,000 feet of the lower part of the Paso Robles Formation is also inundated in Johnson Canyon when the reservoir is full. This sequence of the lower part of the Paso Robles Formation consists chiefly of sand and coarse gravel, but, as elsewhere in the basin, it contains abundant interstitial clay. It is, therefore, less permeable than the upper part of the Paso Robles Formation and has a relatively low transmissibility.

All the water wells in the area north and northwest of Lake Cachuma were first canvassed in 1963 and monthly water-level measurements were made in 1963-64. The well nearest Lake Cachuma is a stock well in Johnson Canyon (6N/29W-17A1). It penetrates both the terrace gravel and the Paso Robles Formation which are inundated in parts of Cachuma and Santa Cruz Canyons when the lake is full. In 1963-64 the water level in this well stood at an average elevation of about 705 feet above sea level or 45 feet below the water level of the full lake. The well is about 1,200 feet north of the lake and when the water surface in the lake stands at 750 feet above sea level, a hydraulic gradient of 190 feet per mile exists between the lake and the well. Because the lake is seldom filled to capacity, the average recharge rate to the aquifer near well 6N/29W-17A1 might be quite low. However, prior to the periodic water-level measurements which began in 1963, a steeper gradient may have existed and considerable recharge from the lake could have reached the area of the well. Unfortunately, no reliable data are available concerning pre-1963 water levels in that area.

Domestic well 6N/29W-8P1 is about 2,800 feet to the west of well 6N/29W-17A1. The well is 250 feet deep and draws water entirely from the Paso Robles Formation. When the well was drilled in 1934, the static water level was 198 feet below the land surface. In March 1964 the water level was 221 feet below the land surface; it was 1 foot lower the following December. These measurements indicate an apparent water-level decline of 23 feet during the period 1934-64. The actual static-level decline in the area may be less because the well is presently pumped at least 12 hours each day. The 1964 measurements may be affected by a local cone of depression due to the low transmissibility of the aquifer. The elevation of the water table in well 6N/29W-8P1 in March 1964 was 679 feet above sea level. This would mean that a hydraulic gradient of about 115 feet per mile exists between the lake surface, when full, and the well. According to the owner of the well, the water level has not risen in recent years. Therefore, recharge to the aquifers from Lake Cachuma probably has been small in this area.

The 1964 water-level-contour map (fig. 3) shows that north of Lake Cachuma in the Santa Ynez upland basin the general movement of ground water is toward the lake.  There is no conclusive evidence that recharge from Lake Cachuma has affected water levels in wells near the lake, although it probably has done so to some extent.  The low local gradients between the lake and nearby wells suggest that recharge from the lake to the ground-water basin in this area has been of minor significance.

When Lake Cachuma was first filled as a result of heavy rains in 1958, recharge to the more permeable parts of the Careaga Sand and the Paso Robles Formation probably occurred.  Since that time, however, falling water levels and the gradual sealing off of the unconsolidated deposits beneath the lake by the deposition of a layer of fine sediment and organic matter over the bottom of the reservoir have probably reduced the annual increment of recharge to a negligible quantity.  It is concluded that the total recharge to the ground-water basin from Lake Cachuma is minor and that it need not be considered quantitatively in the hydrologic inventory.

Total ground-water recharge.--The total recharge to the ground-water basin is equal to the sum of the infiltration of rain, return of irrigation water, and seepage losses from streams.  For the period 1946-64 infiltration of rain amounted to about 70,000 acre-feet, infiltration of irrigation water was approximately 29,000 acre-feet, and seepage losses from streams about 59,000 acre-feet.  The total recharge to the ground-water basin for the period 1946-64 was about 158,000 acre-feet.


Perennial Yield


The perennial yield of an aquifer or a ground-water basin may be defined as the rate at which water can be pumped from wells year after year without decreasing the quantity of water in storage to the point where pumping lifts become economically unfeasible or where the quality of water deteriorates.  The Santa Ynez upland basin has a large quantity of water in storage that can be used before the economic limits of pumping are approached.  When those limits are finally reached, the perennial yield of the basin will be equal to the average rate of natural recharge or discharge.

To make an exact estimate of the perennial yield of the Santa Ynez
upland basin is impossible because of inadequate data for some of the items
of inflow and outflow in the hydrologic budget.  Reference to the
limitations of available data was made in preceding paragraphs.  However,
insofar as the data permit, the elements of the hydrologic budget of the
Santa Ynez upland ground-water basin for 1946-64, a period of relatively
deficient precipitation, are estimated in the following table:

| Ground-water outflow (acre-feet) | | Ground-water inflow (acre-feet) | |
|---|---|---|---|
| Pumpage | 146,000 | Infiltration of rain | 70,000 |
| Evapotranspiration | 19,000 | Seepage losses from streams | 59,000 |
| Outflow in streams | 53,000 | Return of irrigation water | 29,000 |
| Total | 218,000 | | 158,000 |
| | | Storage depletion | 60,000 |
| | | Total | 218,000 |

The above data indicate that, with average yearly pumpage of
7,700 acre-feet and natural outflow of 3,700 acre-feet, there was an
estimated net depletion in storage of 60,000 acre-feet, or 3,200 acre-feet
per year.  The total depletion of water in storage was only about 6 percent
of the estimated 1 million acre-feet of usable ground water stored in the
basin.  Ground-water replenishment during the period 1946-64, by the
infiltration of rain and seepage losses of streams, was about
6,800 acre-feet per year.

If optimum use of all ground water in the basin is to be obtained,
proper management and water-development practices must be applied to limit
natural discharge from the basin and to prevent any significant
deterioration in chemical quality of the water.  If this is accomplished,
the perennial yield of the basin will be equal to the long-term natural
recharge or discharge.  Natural recharge in the Santa Ynez upland ground-
water basin is the sum of the infiltration of rain and seepage losses of
streams.  The estimated recharge rate of 6,800 acre-feet for the period
1946-64 suggests that long-term recharge, and hence the perennial yield of
the basin, is on the order of 7,000 to 7,500 acre-feet per year.

## Quality of Water

Water samples were collected from 19 wells which draw primarily from the Paso Robles Formation. Chemical analyses of these samples are shown in table 6.

Most of the ground water in the Santa Ynez Upland basin meets the standards set for irrigation. The chemical data on water samples collected from wells in the main area of withdrawal in the upland show that ground water in the area has a low sodium hazard and a medium to high salinity hazard. Boron concentrations are generally less than 0.2 ppm and are within the tolerance limits of even the most sensitive plants.

The analyses indicate that ground water in the Santa Ynez upland basin is suitable for general domestic and stock use. The drinking water standards of the U.S. Public Health Service (1962) set the recommended limits for total dissolved solids at 500 ppm. However, if such a water is not available, a dissolved-solids content of 1,000 ppm may be permitted (U.S. Public Health Service, 1962, p. 34). In the Santa Ynez upland area, ground water generally contains less than 1,000 ppm of total dissolved solids. Data available in the files of the U.S. Geological Survey indicate that there has been no significant change in water quality in recent years.

Hardness is reported in table 6 as carbonate hardness and as noncarbonate hardness. Carbonate hardness is frequently referred to as temporary hardness and noncarbonate hardness as permanent hardness. These terms came into use because much of the carbonate hardness can be removed from water by boiling. Carbonates and bicarbonates of magnesium and calcium are the main causes of carbonate hardness, and the sulfate and chloride salts cause noncarbonate hardness. Hardness is objectionable in a water supply because of its scale-forming and soap-consuming properties. If water is to be used for ordinary domestic purposes, hardness does not become particularly objectionable until it reaches a level of about 100 ppm. The total hardness of the ground-water samples collected in the Santa Ynez upland basin averaged about 450 ppm. The water would be classed as very hard but could be readily softened for domestic use by commercial processes or home water softeners.

TABLE 6.—Chemical analyses of water from wells

[Analyzing laboratory: CDWR, California Department of Water Resources]

| Well number | Date of collection | Depth of well (feet) | Water temperature (°F) | Silica ($SiO_2$) | Iron (Fe) | Calcium (Ca) | Magnesium (Mg) | Sodium (Na) | Potassium (K) | Bicarbonate ($HCO_3$) | Carbonate ($CO_3$) | Sulfate ($SO_4$) | Chloride (Cl) | Fluoride (F) | Nitrate ($NO_3$) | Boron (B) | Dissolved solids — Calculated (Sum of determined constituents) | Dissolved solids — Residue on evaporation at 180°C | Hardness as $CaCO_3$ | Noncarbonate hardness as $CaCO_3$ | Percent sodium | Specific conductance (micromhos at 25°C) | pH | Analyzing laboratory |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| U.S. Public Health Service drinking-water standards (1962) | | | | | 0.3 | | | | | | | 250 | 250 | | 45 | | 500 | 500 | | | | | | |
| 6N/29W- 7L2 | 5-18-64 | | 68 | | | 58 | 29 | 21 | 0.8 | 288 | 12 | 4 | 32 | 0.2 | 3 | 0.05 | 300 | | 262 | 6 | 15 | 557 | 8.4 | CDWR |
| 8P1 | 5-18-64 | 250 | 72 | | | 64 | 39 | 22 | 1 | 389 | 0 | 3 | 30 | .2 | 4 | .02 | 354 | | 319 | 0 | 13 | 650 | 8.2 | CDWR |
| 3X1 | 5-18-64 | | 69 | | | 65 | 26 | 64 | 3 | 405 | 0 | 87 | 84 | .4 | 4 | .15 | 563 | | 396 | 64 | 26 | 989 | 7.9 | CDWR |
| 17A1 | 5-18-64 | | 66 | | | 71 | 37 | 17 | .8 | 382 | 0 | 4 | 30 | .3 | 6.5 | .03 | 358 | | 330 | 17 | 10 | 668 | 7.6 | CDWR |
| 18G1 | 5-18-64 | | 68 | | | 128 | 100 | 265 | 21 | 525 | 0 | 709 | 86 | .8 | 45 | 1.2 | 1,646 | | 730 | 300 | 43 | 2,280 | 7.3 | CDWR |
| 6N/30W- 1Q1 | 6- 1-64 | | 68 | | | 54 | 99 | 48 | 1 | 600 | 0 | 62 | 56 | .3 | 3 | .24 | 635 | | 540 | 48 | 16 | 1,090 | 8.1 | CDWR |
| 2N1 | 5-18-64 | | 61 | | | 38 | 32 | 122 | 4 | 434 | 0 | 48 | 64 | .1 | .6 | .20 | 521 | | 225 | 0 | 54 | 912 | 7.9 | CDWR |
| 7C4 | 6- 1-64 | 116 | 69 | | | 30 | 52 | 21 | 1 | 270 | 0 | 12 | 70 | .1 | 9.8 | .07 | 378 | | 287 | 66 | 14 | 654 | 7.8 | CDWR |
| 12E1 | 5-18-64 | | | | | 51 | 41 | 25 | 1 | 321 | 0 | 9.6 | 50 | .2 | 5.5 | .02 | 376 | | 296 | 33 | 15 | 662 | 7.9 | CDWR |
| 24H1 | 10-13-64 | | | | | 100 | 48 | 50 | 3 | 295 | 0 | 269 | 24 | .3 | 0 | .33 | 768 | | 449 | 207 | 19 | 960 | 8.0 | CDWR |
| 6N/31W- 1P3 | 9-21-62 | 503 | 68 | 57 | | 82 | 71 | 44 | 2 | 384 | 0 | 211 | 47 | .1 | 4.0 | .13 | 776 | | 432 | 102 | 16 | 1,020 | 8.0 | CDWR |
| 7N/29W-29R2 | 6- 1-64 | | 66 | | | 57 | 74 | 27 | 1 | 500 | 0 | 49 | 29 | .2 | 3 | .20 | 471 | | 446 | 36 | 11 | 873 | 7.5 | CDWR |
| 7N/30W-16H1 | 6- 3-64 | | 68 | | | 47 | 70 | 26 | 1 | 454 | 0 | 18 | 47 | .3 | 6 | .12 | 475 | | 404 | 32 | 12 | 852 | 7.7 | CDWR |
| 24Q1 | 6- 1-64 | 45 | 71 | | | 61 | 88 | 75 | 3 | 647 | 0 | 24 | 82 | .4 | 17 | .23 | 702 | | 515 | 0 | 24 | 1,210 | 7.5 | CDWR |
| 25G1 | 6- 1-64 | | 69.5 | | | 22 | 75 | 119 | 3 | 542 | 0 | 30 | 105 | .1 | 0 | .15 | 632 | | 363 | 0 | 41 | 1,147 | 7.8 | CDWR |
| 33M1 | 6- 1-64 | 349 | | | | 35 | 68 | 22 | 2 | 420 | 0 | 18 | 37 | .2 | 7.3 | .07 | 408 | | 366 | 22 | 11 | 739 | 7.9 | CDWR |
| 7N/31W-23N3 | 7-17-63 | | 63 | | | 86 | 80 | 42 | 1.5 | 471 | 0 | 194 | 26 | .68 | 12 | .11 | 720 | | 544 | 158 | 14 | 1,060 | 7.4 | CDWR |
| 31D1 | 6- 3-64 | 345 | 66 | | | 30 | 21 | 28 | 1 | 198 | 0 | 10 | 49 | .1 | 20 | .03 | 290 | | 187 | 25 | 25 | 507 | 7.4 | CDWR |
| 36L2 | 6- 1-64 | | 69 | 43 | | 94 | 71 | 39 | 2 | 420 | 0 | 203 | 39 | .5 | 6.3 | .12 | 749 | | 525 | 181 | 14 | 1,070 | 7.5 | CDWR |

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